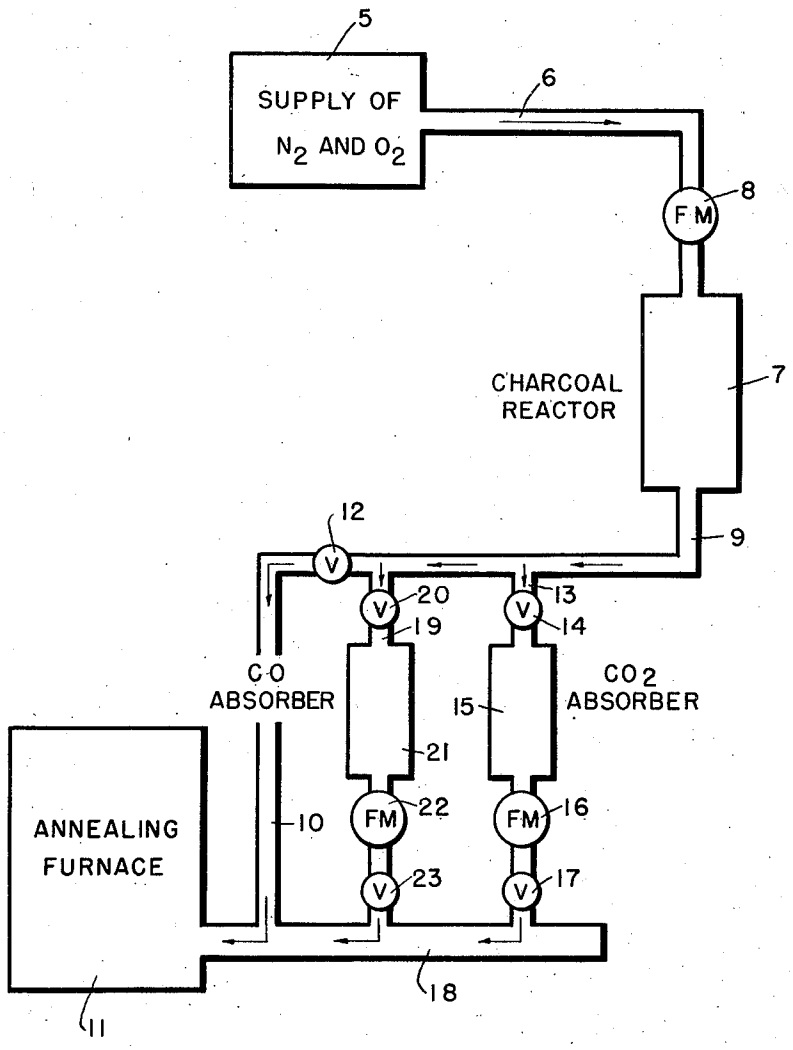
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CONTROLLED ATMOSPHERE FOR HEAT-TREATING METALS

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CONTROLLED ATMOSPHERE FOR HEAT-TREATING METALS

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This invention relates to the heat treatment of metals and particularly to annealing thereof in the presence of non-oxidizing atmospheres to control the carburization or decarburization and to prevent the discoloration of the surfaces of the metal treated. Although principally concerned with the annealing of steel, it is applicable to the treatment of other metals which are subject to oxidation or other modification at high temperatures.

It has been suggested heretofore that annealing may be accomplished in the presence of an atmosphere of nitrogen containing carbon dioxide and carbon monoxide. In accordance with the earlier procedure, nitrogen containing not more than about 5% of oxygen is passed through carbon which must be heated to a temperature substantially in excess of the temperature employed in the annealing furnace. Whatever merit the procedure may have, it obviously involves a difficulty of properly adjusting and maintaining the relative temperatures and other conditions of operation.

It is the object of the present invention to provide a simple and economical method and apparatus for producing and utilizing a non-oxidizing atmosphere in the heat treatment of metals.

Other objects and advantages of the invention will be apparent as it is better understood by reference to the following specification and the accompanying drawing, which illustrates diagrammatically an apparatus suitable for the practice of the invention.

When steel, for example, of given carbon content, is heat treated at a given temperature in the presence of gas containing nitrogen, carbon monoxide and carbon dioxide, the carburizing or decarburizing effect is governed by the relative concentrations of carbon monoxide and carbon dioxide in the gas. This is expressed by the ratio

$$\frac{(P_{CO})^2}{P_{CO_2}}$$

in which P_{CO} and P_{CO_2} are the partial pressures which are proportional to concentration. If the ratio is greater than some fixed value expressed as K (the equilibrium constant), the steel will be carburized. If the ratio is less than K, the steel will be decarburized. If the ratio is equal to K, the result is neither carburization nor decarburization. The value of K differs, depending upon the carbon content of the steel and the heat treating temperature. Thus, for 0.40% carbon steel, heat treated at 800° C., $K=3$. At 900° C., $K=11$. For an 0.80% carbon steel, the corresponding values of K are 6 and 20, respectively.

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Similarly, when a gas consisting of nitrogen and oxygen is passed over charcoal at a given temperature and equilibrium is established, the resulting gas will consist of nitrogen, carbon monoxide and carbon dioxide in which the relative concentrations of carbon monoxide and carbon dioxide are fixed, so that the ratio

$$\frac{(P_{CO})^2}{P_{CO_2}}$$

is constant. Thus, a gas containing nitrogen and oxygen, when passed over charcoal at 700° C., will produce a gas containing carbon monoxide and carbon dioxide in proportions such that ratio

$$\frac{(P_{CO})^2}{P_{CO_2}}=1.06$$

If the charcoal is at 1000° C., the ratio is 146.5. The result is the same, regardless of the percentage of oxygen in the original gas.

Advantage is taken of these facts in accordance with the present invention by producing the desired gaseous atmosphere at any given temperature, regardless of the temperature of annealing, and then modifying the composition of the gas to the ratio desired for annealing of the particular metal at the predetermined temperature. The carbon bed may thus be operated at a temperature varying over a wide range, but preferably between 500° and 1200° C. Adjustment of the ratio of carbon monoxide and carbon dioxide is then effected readily by selectively absorbing either carbon monoxide or carbon dioxide until the desired ratio of carbon monoxide to carbon dioxide for the annealing atmosphere is attained. Thus, if the gas produced has an excess of carbon monoxide, it is passed through a carbon monoxide absorber. If the carbon dioxide is too high, the gas is passed through a carbon dioxide absorber. Only a portion of the gas need be treated ordinarily, and the balance is bypassed to the annealing furnace, being mixed with the modified gas to produce an atmosphere of the desired composition.

As a result of this procedure, it is possible to avoid the difficulties hereinbefore mentioned, and particularly that of maintaining the carbon or charcoal at a predetermined temperature in excess of that employed in the annealing furnace. It is much easier to attain and maintain an atmosphere of the desired ratio of carbon monoxide to carbon dioxide, and since this ratio is critical, depending upon the carbon content and

temperature of treatment, the desired results in annealing are more readily attained by the practice of the invention as herein described.

Referring to the drawing, 5 indicates a source of supply of nitrogen and oxygen. This preferably is a liquefaction column in which air is liquefied and rectified to afford a supply of the desired gases. The effluent nitrogen from such a column may and usually does contain varying proportions of oxygen. A gas containing upward to 10% of oxygen may be employed readily where, as in the earlier method hereinbefore mentioned, it is necessary to restrict the oxygen content to not over about 5%. In the present procedure, the proportion of oxygen in the nitrogen is not critical because the composition of the resulting combustion gases is corrected to give the proper ratio of carbon monoxide and carbon dioxide for the particular operation involved.

The mixture of nitrogen and oxygen is delivered by a pipe 6 to a reactor 7 which is filled with carbon, preferably in the form of charcoal. The reactor is heated in any suitable manner, for example electrically by the use of resistance or by the application of waste hot gas from the annealing furnace. The temperature of the reactor is likewise not critical, but is preferably maintained between 500° and 1200° C. Preferably a flow meter 8 is disposed in the pipe 6 in order to regulate the amount of the gaseous mixture delivered to the reactor. The gaseous products of combustion in the reactor 7 are delivered through a pipe 9. They will consist of nitrogen principally, with varying proportions of carbon monoxide and carbon dioxide, depending upon the temperature maintained in the reactor. These gases flow through the pipe 9 to a pipe 10 and thence to the annealing furnace 11. A valve 12 is disposed in the pipe 9 to regulate the flow.

Since the gases from the reactor 7 will rarely contain the proper ratio of carbon monoxide and carbon dioxide for the treatment of a steel of particular carbon content at a particular annealing temperature, it is necessary to modify the ratio. This is accomplished by withdrawing portions of the gas and subjecting them to analysis. If there is an excess of carbon dioxide, the gas is withdrawn through a pipe 13 controlled by a valve 14 and delivered to an absorber 15 which may be filled with any suitable material adapted to absorb carbon dioxide. There are numerous materials suitable for this purpose, including potassium hydroxide, anhydrous sodium oxide, soda lime, Ascarite and monoethanolamine. After passing through the absorber, the gas is delivered through a flow meter 16 and valve 17 to a pipe 18 connected to the pipe 10. By thus absorbing carbon dioxide from a portion of the gas from the reactor 7, the ratio of carbon monoxide to carbon dioxide may be varied at will to afford the proper atmosphere.

Similarly, if the carbon monoxide is in excess, a portion of the gas is withdrawn through a pipe 19 controlled by a valve 20 and delivered to an absorber 21. A suitable material for the absorption of carbon monoxide is cuprous chloride, acid or basic. Other materials may, however, be employed. From the absorber 21, the gas is delivered through a flow meter 22 and valve 23 and thence to the pipe 18 which permits it to

mingle with the gas flowing through the pipe 10 to the annealing furnace 11.

Thus, by absorbing a portion of the carbon monoxide or carbon dioxide, depending upon which is in excess, the composition of the gas delivered to the annealing furnace may be varied at will and readily adjusted to afford the desirable ratio for the particular purpose. The operator has merely to determine by analysis in the usual manner which gas is in excess, and then to manipulate valves to direct the desired proportion of the combustion product through one or the other of the absorbers 15 and 21 to secure a gas of the preferred composition.

Various changes may be made in the details of procedure and in the apparatus as described without departing from the invention or sacrificing the advantages thereof.

I claim:

1. In the method of annealing steel of a predetermined carbon content in which the steel is heated at a predetermined temperature while in contact with a gas containing N_2, and CO and CO_2 in a desired predetermined ratio; the improvement in forming said gas which comprises selectively absorbing from a portion of a gas containing N_2, and CO and CO_2 in a ratio other than the desired predetermined ratio the carbon-oxygen constituent which is present in excess of the desired ratio and mixing the gas depleted in said constituent with the remainder of the gas, the amount of said constituent which is selectively absorbed being such that the gas resulting from said mixing will contain CO and CO_2 in the desired predetermined ratio.

2. In the method of annealing a steel of a predetermined carbon content in which the steel is heated at a predetermined temperature while in contact with a gas containing N_2, and CO and CO_2 in a desired predetermined ratio; the improvement in forming said gas which comprises passing N_2 and O_2 through a bed of carbon at an elevated temperature between 500° C. and 1200° C. with resultant formation of a gas containing N_2, and CO and CO_2 in a ratio other than in the desired predetermined ratio, selectively absorbing from a portion of said gas the carbon-oxygen constituent which is present in excess of the desired ratio, and mixing the gas depleted in said constituent with the remainder of the gas, the amount of said constituent which is selectively absorbed being such that the gas resulting from said mixing will contain CO and CO_2 in the desired predetermined ratio.

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